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Auricular Exostoses in the Prehistoric Population of Gran Canaria

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ABSTRACT Auditory exostoses are bone anomalies located in the external auditory canal. The bulk of clinical observations and some experimental data support the idea that their development depends on prolonged exposure to cold water. This study was performed in order to analyze the prevalence of auditory exostoses among the prehispanic population of Gran Canaria, comparing it between men and women and between individuals buried in coastal regions and central highlands. We analyzed 323 crania, 41 of which showed auditory exostoses. Marked differences in prevalence were observed between the individuals buried in the central highlands (0.88%) and those buried in coastal regions (40.21%). Among the latter, the prevalence was similar in men (41.67%) and in women (38.89%). These data support the hypothesis that individuals buried in coastal regions performed economic activities related to exploitation of marine resources, whereas those living in the central highlands did not; however, diachronic variation cannot be excluded. Am J Phys Anthropol 112:49–55, 2000.

Auditory hyperostoses are bony anomalies located on either the posterior wall or the floor of the lateral aspect of the tympanic portion of the temporal bone. This definition encompasses two distinct entities, the so-called auditory exostoses, which are lesions with an extensive base, mainly located on the floor of the external auditory canal, and auditory osteomata, which show a small and pedunculated base, which only arise from the tympanomastoid and tympanosquamous sutures, and project into the acoustic meatus, narrowing the lumen of the external auditory canal (Gervais, 1989; Kemink and Graham, 1982). However, these definitions have not been universally accepted, and it is unclear whether they truly represent distinct entities (Fenton et al., 1996). Many clinicians and anthropologists prefer to use the term "auditory exostosis" to denote all discrete auditory lesions growing in the auditory canal.

These lesions are spheroid or oval, vary in size, and are limited in occurrence to late adolescents and adults. It is generally believed that habitual exposure of the ear canal to cold water triggers an inflammatory reaction in the soft tissue, ultimately leading to osteogenic activity, but the mechanism(s) by which bone formation takes place remains speculative. It is well-known that several cytokines and growth factors, such

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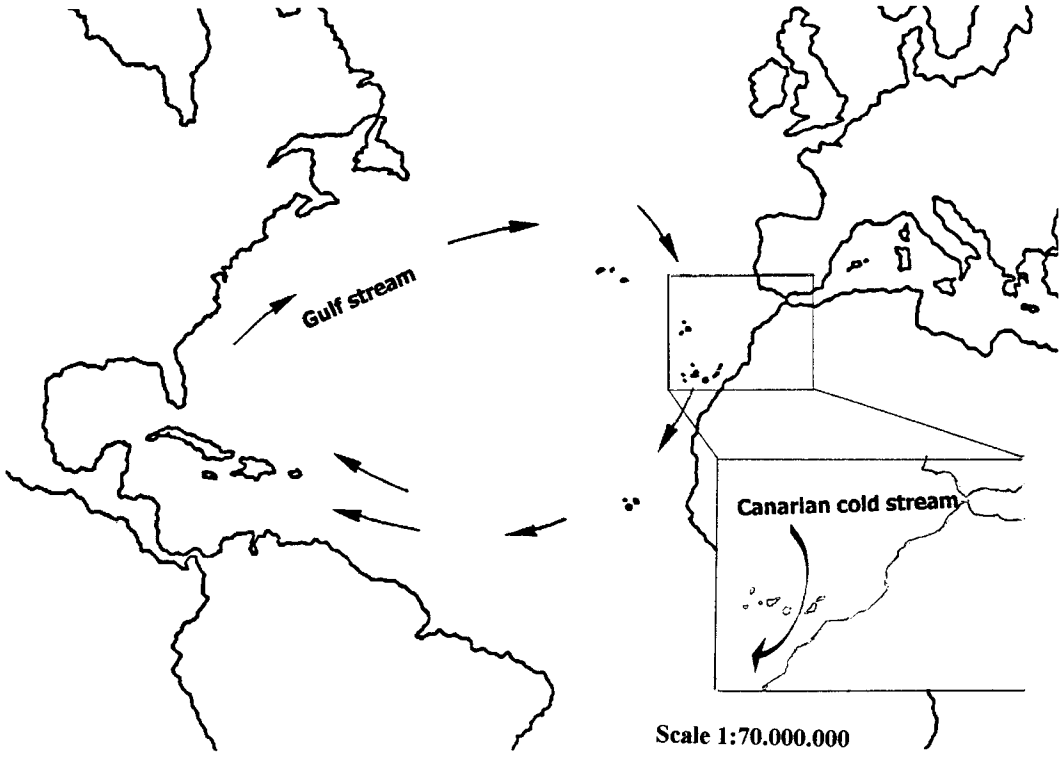

Fig. 1. Geographical situation of the Canary Islands.

as interleukin 1 and 6, tumor necrosis factors α and β, transforming growth factor β, and interferon γ, among others, modulate the activity and function of osteoblasts and osteoclasts (Lerner, 1994; Mundy et al, 1995). In this sense, cytokines released by sensitized T-lymphocytes, macrophages, and epithelial cells are involved in the bone destruction observed in periodontal disease (Graves, 1999). Several growth factors, also released during the inflammatory response, counteract bone resorption and lead in fact to net bone formation (Mohammed et al., 1998), playing a key role in fracture repair (Bolander, 1992). It is possible that an imbalance between the local effect of osteogenic growth factors and bone-resorptive cytokines during repeated episodes of otitis externa acquired during exposure to cold water may lead to the formation of auditory exostoses.

Whatever the case, the presence of exostoses has been linked to diving in cold water (normally below 19°C). Some experimental data and anthropological and clinical observations support this hypothesis (Ito and Ikeda, 1998; Kennedy, 1986; Chaplin and Stewart, 1998). Thus, the finding of these exostoses in past population groups may provide information about economic activities. In this sense, several studies have shown variable prevalence of this trait in ancient population groups, as diverse as prehistoric Chileans (Standen et al, 1997), Mesolithic inhabitants from Yugoslavia (Frayer, 1988), ancient Romans (Manzi et al, 1991), Australian Aborigines (Roche, 1964; Ponder, 1984), ancient Lithuanians (Sakalinskas and Jankauskas, 1993), and other population groups (Kennedy, 1986).

The Canary Islands are located off the northwestern coast of Africa, at a latitude 28° North (Fig. 1). The Canarian cold stream, which is particularly intense in the eastern part of the Archipelago, leads to sea waters relatively cooler than expected according to latitude, especially in the eastern islands (approximately 17°C in winter and

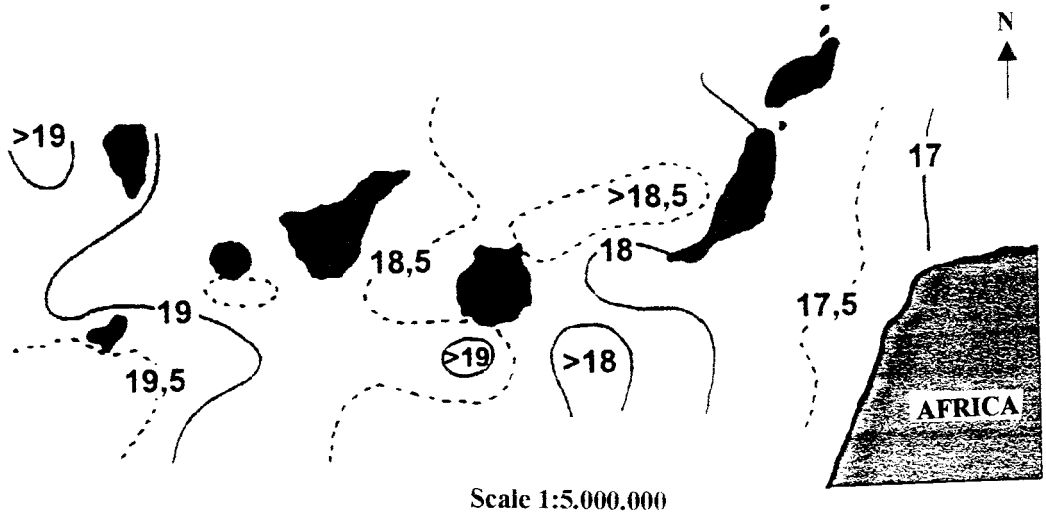

Fig. 2. Sea temperature (in °C) in April–May in the Canary Archipelago.

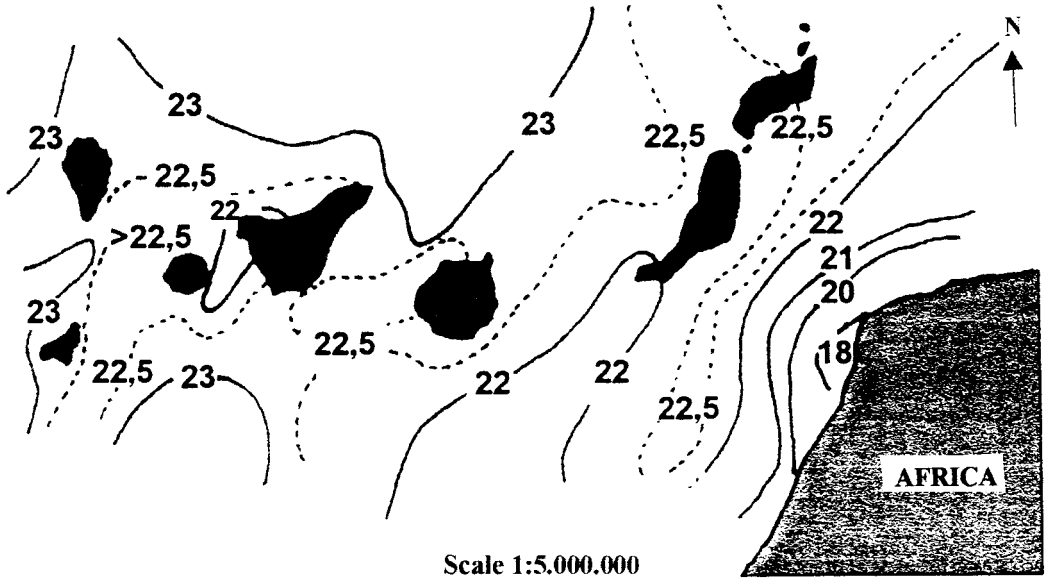

Fig. 3. Sea temperature (in °C) in August–September in the Canary Archipelago.

22–23°C in summer, Figs. 2, 3). The presence of cold water, in which human immersion occurs, theoretically supports the development of auricular exostoses. Based on anecdotical observations (Dutour and Onrubia-Pintado, 1991; Betancor-Rodríguez and Velasco-Vázquez, 1998), we performed the present study in order to determine the prevalence and characteristics of auricular exostoses in a wide sample of crania belonging to prehispanic inhabitants from Gran Canaria, and to explore the eventual differences between individuals buried in coastal regions and in the central highlands.

MATERIALS AND METHODS

We analyzed 323 crania belonging to prehispanic adult individuals from Gran Cana-

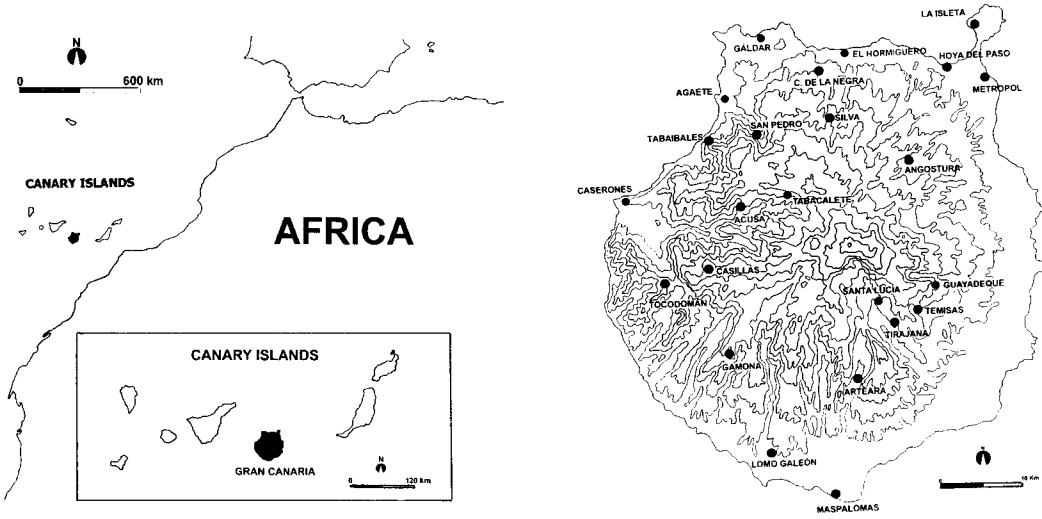

Fig. 4. Geographical distribution of the archaeological sites on Gran Canaria.

TABLE 1. Radiocarbon dates for samples of some of the burials analyzed

Archaeological site	Date	Author
Caserones	1700 ± 100 BP	Del Arco et al., 1977
Caserones	1140 ± 100 BP	Jiménez Gómez et al., 1993
Hormiguero	1740 ± 90 BP	Del Arco et al., 1977
Guayadeque	1213 ± 60 BP	Hernández Pérez, 1982
Guayadeque	1410 ± 60 BP	Hernández Pérez, 1982
Acusa	1380 ± 60 BP	González Antón and Tejera Gaspar, 1990
Agujero	875 ± 60 BP	Fusté Ara, 1961
Metropole	540 ± 70 BP	Velasco Vázquez and Betancor Rodríguez, 1997

ria, housed at the Museo Canario (Las Palmas). These skeletal remains were found in several burial sites; their geographical distribution is shown in Figure 4. There are some radiocarbon dates for samples from these burials, which are shown in Table 1. Sex was established following the criteria of Krogman and Iscan (1989); using this method, 179 belonged to males and 129 to females, and in 15 cases sex was not unequivocally diagnosed. Ninety-seven individuals were buried near the coast, whereas the others were buried in caves in the central mountains.

The external auditory canal was examined with the naked eye, looking for the presence and location (superior, inferior, anterior wall, or posterior wall) of exostoses. Also, we recorded if these exostoses were uni- or bilateral, and to what extent they occluded the auditory canal (less than one third, 1/3–2/3, and more than 2/3; Standen et al., 1997).

RESULTS

We found auricular exostoses (Fig. 5) in 41 out of the 323 individuals from Gran Canaria (12.68%). They appeared slightly, albeit nonsignificantly, more in males (27/179, 15.08%) than in females (14/129, 10.85%).

Bilateral exostoses were observed in 77.55% of those individuals with exostoses (in 81.25% of males and 73.33% of females). Regarding location, most were located posteroinferiorly (75.51%), and 22.44% anterosuperiorly.

The prevalence of exostoses in each burial site is recorded in Table 2. A marked difference was observed between prevalence in coastal individuals (39/97, 40.21%) compared with those buried in the central highlands (2/226, 0.88%; $X^2 = 91.3$, $P < 0.0001$).

DISCUSSION

The proportion of auricular exostoses among the prehispanic inhabitants of Gran Canaria buried in coastal regions is higher

Fig. 5. Auditory exostoses, occluding more than 2/3 of the diameter of the auditory canal.

than the figures reported for many population groups. Manzi et al. (1991) found that 31.3% of crania belonging to Imperial Romans from Isola Sacra showed exostoses; Frayer (1988) reported a proportion of 34.21% among mesolithic Yugoslavians; Standen et al. (1997) reported a proportion of 30.7% in coastal Chileans, whereas Gerszten et al. (1998) found auditory exostoses in only 5% of coastal inhabitants from North Chile and South Peru. However, auricular exostoses were found in an even higher proportion in Australian Aborigines (Roche, 1964) and in Indians from Kentucky (Kennedy, 1986). In modern population groups, the prevalence of auditory exostoses ranges from 80% in Japan's surfers (Umeda et al., 1989), 73% in New Zealand surfers (Chaplin and Stewart, 1998), 26% in U.S. navy divers (Karageannes, 1995) to 6.36% in inhabitants of coastal regions (DiBartolomeo, 1979).

Although formerly considered a genetic trait (Berry, 1975), there is general agreement (except for some investigators; see Hutchinson et al., 1997) concerning the relationship between the formation of exostoses and prolonged exposure to cold water (Deleyiannis et al., 1996; Ito and Ikeda, 1998; Chaplin and Stewart, 1998). In our study, a striking result is the highly significant differences regarding prevalence of exostoses between the populations buried in the central highlands and the coast. This finding may reflect differences in exploitation of marine resources. Indeed, in previous studies we found high bone Sr in skeletal remains from both highland and coastal burials (González-Reimers and Arnay-de-la-Rosa, 1992), but lower bone Ba and Ba/Sr ratios in the latter (Table 3), thus suggesting a greater dietary reliance on marine products by the inhabitants of the coastal regions (Velasco-Vázquez, 1997). Thus, the

TABLE 2. Prevalence of auditory exostoses in the burial sites mentioned in this study

Site	Exostoses/ total cases	Men	Women	Undefined sex
Temisas	0/8 (0%)	0/3 (0%)	0/4 (0%)	0/1 (0%)
Santa Lucía	0/17 (0%)	0/13 (0%)	0/3 (0%)	0/1 (0%)
Tirajana	0/22 (0%)	0/12 (0%)	0/10 (0%)	
Guayadeque	0/98 (0%)	0/45 (0%)	0/44 (0%)	0/9 (0%)
Arteara	0/4 (0%)	0/2 (0%)	0/2 (0%)	
Agujero	25/42 (59.5%)	16/26 (61.5%)	9/16 (56.2%)	
Acusa	1/20 (5%)	1/10 (10%)	0/10 (0%)	
Tabacalete	0/33 (0%)	0/16 (0%)	0/16 (0%)	0/1 (0%)
Agaete	1/5 (20%)	1/4 (25%)	0/1 (0%)	
Caserones (La Aldea)	1/11 (9.1%)	0/6 (0%)	1/5 (20%)	
Todocomán	1/1 (100%)	1/1 (100%)		
Metropole	7/8 (87.5%)	3/3 (100%)	4/5 (80%)	
La Isleta	0/14 (0%)	0/7 (0%)	0/7 (0%)	
Lomo Galeón	3/4 (75%)	3/3 (100%)	0/1 (0%)	
San Pedro	0/2 (0%)	0/2 (0%)		
C. de la Negra	0/2 (0%)	0/1 (0%)		0/1 (0%)
Casillas	0/7 (0%)	0/5 (0%)	0/1 (0%)	0/1 (0%)
Hoya del Paso	1/4 (25%)	1/3 (33.3%)	0/1 (0%)	
Hormiguero	0/9 (0%)	0/8 (0%)		0/1 (0%)
Cuesta de Silva	0/2 (0%)	0/2 (0%)		
Angostura	0/9 (0%)	0/6 (0%)	0/3 (0%)	
Tabaibales	1/1 (100%)	1/1 (100%)		
Total	41/323 (12.7%)	27/179 (15.1%)	14/129 (10.9%)	0/15 (0%)

TABLE 3. Mean values of the Ba/Sr molar ratios in bone samples (right tibia) from different archaeological sites from gran canaria

Archaeological site	Number of cases	Ba/Sr molar ratio
Agujero (coast)	15	0.0331 ± 0.0165
Dragonal (coast)	2	0.0288 ± 0.0050
Guayadeque (inland)	54	0.0699 ± 0.0595
Santa Lucía (inland)	5	0.0420 ± 0.0121
Charquitos (inland)	2	0.0413 ± 0.0136
Crusesitas (inland)	6	0.0803 ± 0.0224
Tabacalete (inland)	4	0.0660 ± 0.0300

interpretation of the data derived from bone chemical analysis is in accordance with the different prevalences of exostoses found in this work, which supports the deduction regarding the consumption of marine products by the inhabitants of the coastal regions. In Gran Canaria, although the economy was mainly based on agriculture, there are indeed archaeological remains which point to some consumption of shellfish and fish (Rodríguez Santana, 1996). Also, chroniclers wrote that fishing and shellfishing were complementary activities of the prehispanic people from Gran Canaria (Abreu Galindo, 1977), and as well, that both men and women took part in them. In this regard, we have found that an important proportion of women (38.89%, nearly the same as the proportion of men, i.e., 41.21%) also showed auditory exostoses. Our data as a whole suggest that, despite the relatively small size of Gran Canaria (only 1,532 km^2), the inhabitants of the central highlands did perform economic activities different from those living near the coast.

There is also the possibility of diachronic differences between individuals with bony exostoses and those without them. As shown in Table 1, the sites of Agujero and Metropole, with a high prevalence of exostoses, are relatively recent when compared with Guayadeque, Acusa , Hormiguero, and Caserones, this last being also a coastal site, but with a low prevalence of exostoses (unfortunately, there is no "recent" burial in the highlands). Gran Canaria was densely populated in prehistoric times, with nearly 30–40 inhabitants/km^2 at the time of the Spanish conquest, 520 years ago. It is possible that the population grew during the millennium which spans the time between the individuals from Hormiguero and those from Metropole (Table 1). A more intense exploitation of marine resources may have

occurred in the most recent times compared to the former ones. However, this is purely hypothetical: the first chroniclers who wrote about the economy, social structure, and life style of the inhabitants of Gran Canaria visited the island towards the end of the 14th century and, moreover, archaeological data do not support the existence of diachronic differences.

In conclusion, we found a high prevalence of auditory exostoses among the prehispanic inhabitants of the coastal regions from Gran Canaria, in contrast with the figures observed among the inhabitants of the central highlands. These results may be derived either from differences in economic activities between the two population groups, or from diachronic differences between the more recent individuals, with a high proportion of exostoses, and the most antique ones, with a low proportion of auditory exostoses.

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